UNIVERSITY OF ALASKA FAIRBANKS

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Fairbanks, AK
27 November 2002

Dear Mrs. Neff,

Please find enclosed one original and two copies of our 6-month report of our NOAA/Ocean Explorations project "The hidden ocean: Explorations under the ice of the Western Arctic – Deep-sea benthos diversity and food web structure", NOAA award number NA16RP2627.

On the behalf of my Co-PIs and myself, I would like to thank NOAA again for the recognition and award.

Sincerely,

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The Hidden Ocean: Explorations under the ice of the Western Arctic – Deep-sea benthos diversity and food web structure

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Introduction

Benthic communities below the photic zone (i.e. greater than about 300 m depth) depend in general on food supplied from the water column. In the Arctic, growth and survival of benthic deep-sea organisms is constrained by the flux of food particles to the bottom rather than the low water temperature *per se*. In addition to the supply of organic carbon from the water column, down-slope transport of organic carbon along the bottom boundary layer occurs at the margins of the Arctic basins. This process may enhance local deposition of organic matter and may create rich deposits of skeletal remains from the pelagic environment. On the shallow North American shelves, particle transport from the pelagic realm to the benthos is relatively large during the ice-free period. An impressively high faunal biomass is supported in the areas of the very nutrient-rich and productive Bering Sea-Anadyr water in the northern Bering and Chukchi Seas. In particular, polychaetes, bivalves and amphipods support one of the world's major feedings grounds of the California Gray whale and are an essential food source for other marine mammals.

Although marine scientists and managers have a reasonable understanding of the North American Arctic shelf benthos in terms of species diversity, abundance and biomass as well as benthic-pelagic coupling, little information is available from areas deeper than 200 m. The scarce information about slope and deep-sea benthos in the Canadian Basin is based on collections from early Arctic drifting stations that indicated very low benthic biomass at the few sampled sites. Dominant benthic taxa in terms of abundance were sponges, polychaetes, bivalves and crustaceans. Fewer major benthic groups have been found in the American deep Arctic Ocean than in other deep-sea areas. For example, Monoplacophora, Echinoidea, Bryozoa, and Brachiopoda were thought to be lacking; and available data suggest that diversity is low.

It must be emphasized that this understanding is based in large part on a sharply limited sampling effort. Benthic sampling in the high Arctic deep-sea is a highly challenging undertaking and expeditions have been few until now. However, characterization of the Arctic deep-sea benthos will remain preliminary until additional collections can be recovered, analyzed, and published. The paucity of information in the literature suggests that even modest efforts can add significantly to our overall picture of the Arctic ecosystem. It was our goal within the NOAA Ocean Exploration effort to increase our knowledge of Arctic deep-sea benthic communities and our understanding of trophic processes. During the NOAA Ocean Exploration expedition we have completed a series of benthic stations across the Canadian Basin. By combining sampling by box cores with detailed visual inspection with an ROV, we have obtained new insights into the geographic and topographic variability in benthic fauna. As the findings are analyzed and interpreted, our results will refine the current view of an apparently impoverished Arctic deep-sea fauna.

Objectives and Significance

The work of the benthic group provides the Ocean Exploration program with a biological and ecological perspective on seafloor communities and, to some extend, on processes. The expedition covered a wide area of the Canadian Basin and we found noteworthy geographical differences in the fauna, bottom types, and sediments. The benthos is a living community and a repository of skeletal remains from the water column and regions upslope. Differences among the benthic stations are interesting in themselves, but can potentially offer insight into circulation patterns, slope transport, and climate processes as well.

Our objectives for work related to the benthos in the deep Canadian Basin were as follows:

1) Identify habitats, species diversity/composition, abundance and biomass of major components of the deep benthic fauna in the Canadian Basin and adjacent continental slope using ROV *in situ* imaging in conjunction with analysis of ROV and box core samples.
2) Investigate the food web structure of the benthic community using mostly stable isotope analysis, but also gut content analysis, and ROV *in situ* imaging.
3) Investigate trophic links between the benthic, pelagic and ice-associated food webs of the deep Arctic Ocean, using stable isotope analysis.
4) Measure levels of pollutants to assess the anthropogenic impact on this remote basin.
5) Evaluate skeletal remains in the benthos for possible long-term climate records.

Stations Occupied and Samples Collected

The box core and ROV stations sampled by the benthic team were distributed along the overall cruise track of the LOUIS S. ST. LAURENT; station names were consistent with those used by the overall program. Constraints on sampling occurred due to logistic difficulties encountered during the course of a multidisciplinary program. In addition, malfunctions and lack of spare parts for the coring winches limited the number of box cores taken and the depth of the stations that could be cored. Fortunately, sufficient samples were collected to provide preliminary comparisons among several geographic locations. Maps showing box core and ROV stations are presented in Figure 1.

a b

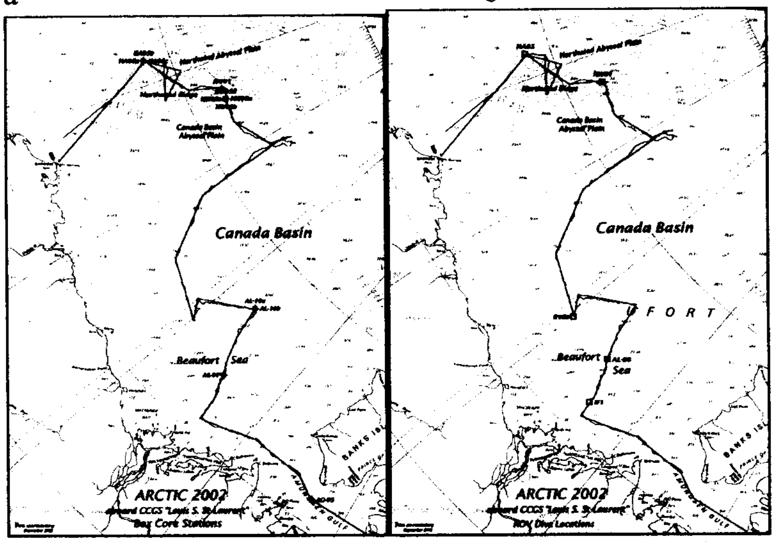

Fig. 1: Cruise track of Louis S. St. Laurent cruise #2002-23 with box core (a) and ROV stations (b). Charts courtesy of Bon van Hardenberg, IOS, Canada.

Table 1 summarizes the results of box coring. Table 2 summarizes the results of the benthic ROV dives. Methods used are described in the following sections.

Table 1. Box core stations and samples collected. Note that subsamples were taken for ancillary investigators in all of the cores. Disposition of the ancillary samples is described in the next section.

Station	**Core**	**Depth**	**Description**	**Samples taken**		
				Quant macro	**Quant meio**	**Tissue**
AG05	1	625	Silt over clay, light tan, 15d 70% filled, surface water lost	yes	yes	yes
AL07	1	1568	Foraminiferan ooze-silt over clay, 10d angle, surface water lost	yes	yes	hardly any
AL10	1	3250	Silt over clay, silt ca. 3-7cm, 60-70%	yes	yes	no (too little)
AL10	2	3250	Silt over clay, silt ca. 3-7cm, 40 cm out of 55cm	yes	yes	no (too little)
NW05	1	ca 2000	Surface water, gastropod shells, hair?, coarse with rocks	yes	yes	no (too little)
NW05	2	1850	Surface water, anemone, hexactinnelid on rocks	yes	yes	no (too little)
NW05	3	1850	Surface water, rock with calcareous tubes and cnidarian tubes	yes	yes	no (too little)
NW01	1	800	60%, slight angle, 2-3 cm organic over clay, surface water	yes	yes	no (too little)
NA05	1	1350	Soft, liquid mud, 5-7 cm, ophiuroid, 60%	yes	yes	some
NA05	2	1350	Soft, liquid mud, ca 5 cm, worm tubes, 70%, water still on	yes	yes	some
NA05	3	1350	Same, some water	yes	yes	some
6 st.	11 cores					

Table 2. ROV dives during OEI-Arctic cruise.

Station	Activity	Dive no. (depth m)	Date	Time in midwater (hrs)	Time on bottom (hrs)	Midwater photos	Benthic photographs
IF1	test	1 (surface)	17/8/02	uncertain	n/a	n/a	n/a
AL08	test	2 (~100)	18/8/02	n/a	n/a	n/a	n/a
AL10	pelagic	3 (2800)	22/8/02	8	n/a	n/a	n/a
RVB1	benthic	4 (2760)	24/8/02	1	3	n/a	348
NA05/4	combined	5 (1800)	31/8/02	7.5	0.5	250	33
NW01	combined	6 (800)	1/9/02	3	1.5	72	145
NA05	combined	7 (1380)	5/9/02	3.5	3.2	99	327

Shipboard methodology and sample processing

Box-coring

We used a 50x50 cm box core with a spade closure to collect samples of benthic sediment (Figure 2). The corer was deployed from an A-frame on the starboard bow of the LOUIS. Station depth was measured with an Elac echosounder. A tilt-activated, acoustic pinger mounted on the spade arm gave a continuous indication of the depth of the corer and provided confirmation that the core had successfully tripped on the bottom. A numbered marker made of buoyant plastic and reflective tape was attached to each core and was rigged so it would be released when the spade arm closed.

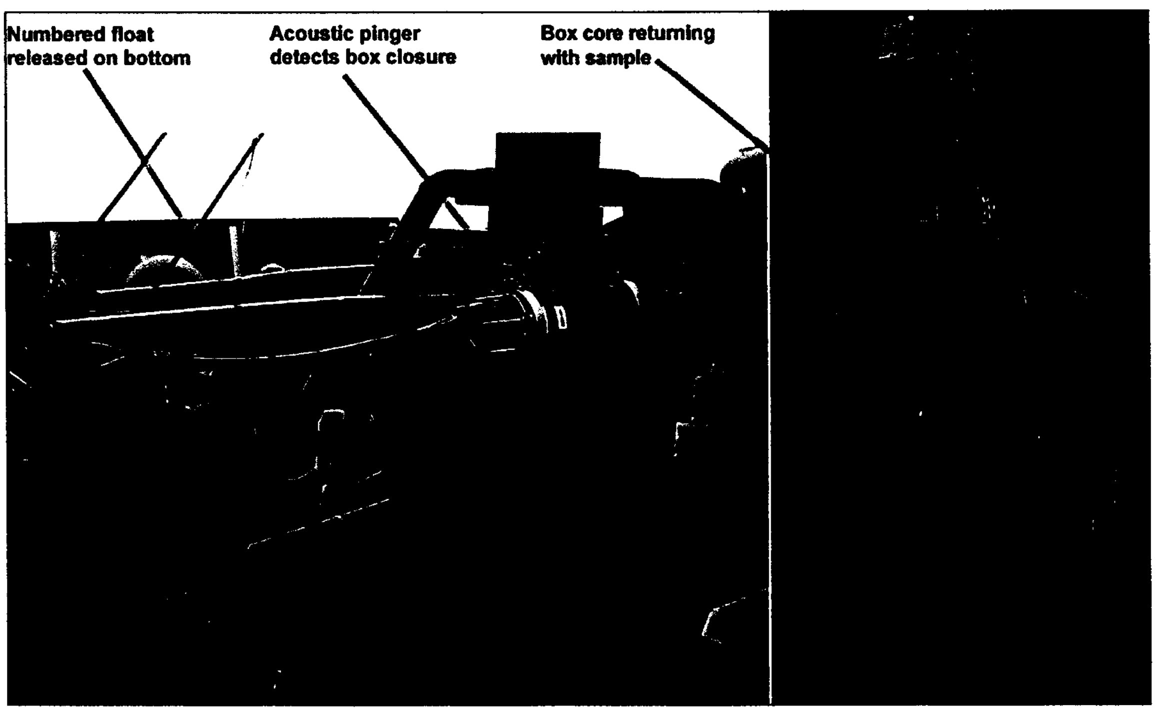

Figure 2. Deck shots of box corer used to collect benthic samples. Left: corer on deck in cocked position. Right: core recovered with spade arm closed.

Upon recovery to the deck, the box cores were photographed and described in a log that noted the color, apparent grain size, and other features (Table 1). Each box core was sub-sampled for a quantitative macrofauna sample (20 x 20 cm), a quantitative meiofauna sample (2 x 50 cc syringes) and tissue samples (remaining organic surface layer) (Fig. 3). The quantitative macrofauna and tissue samples were sieved through 250 µm and 500 µm sieves, respectively. In addition, various surface sediment samples were taken for analyses of bacteria, foraminifera, carbon dating etc. Unfortunately, there was not enough ship time at most station to retrieve sufficient replicate box cores for community analysis.

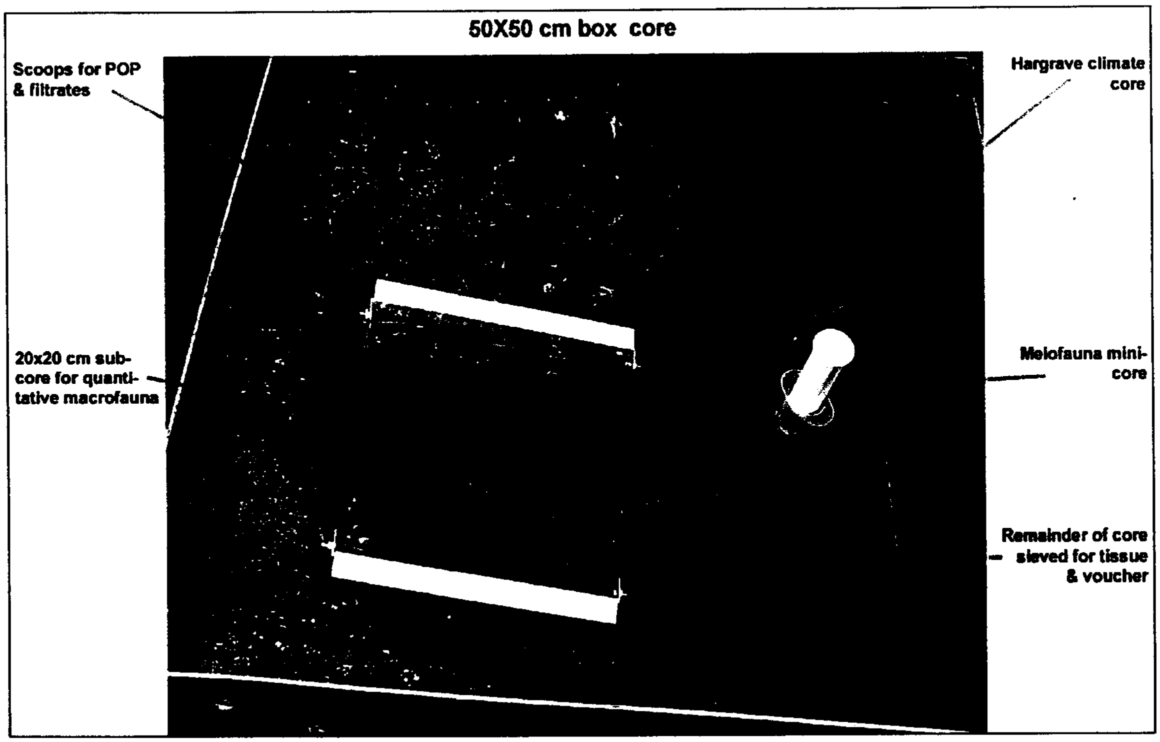

Figure 3. Subsampling of box core. Subcore was sieved with 250 um mesh; remainder with 500 um mesh.

Quantitative samples were preserved in 4% formaldehyde-seawater solution while tissue samples were sorted on ice for voucher specimens as well as stable isotope and pollutant samples. Several stations were so low in biomass and/or did not have sufficient replicates to provide any tissue samples. At stations where sufficient material was present, specimens often were so small that several complete individuals were in most cases pooled to obtain sufficient mass for tissue analysis. For stable isotope analysis, reference for the benthic food web will be phytoplankton and ice algae produced in the euphotic zone. Water and ice samples for this purpose were filtered onto pre-combusted glass-fiber filters in cooperation with the sea ice group (Dr. Gradinger et al.). Pelagic and under-ice organisms for stable isotope based food web and pollutant analyses were kindly provided by the pelagic group (Dr. Hopcroft et al.) from their net tows and by the divers.

ROV Operations

The "Max Rover" ROV by "Deep Sea Systems" was used to photograph and observe the benthic environment (Table 2). We completed three formal benthic surveys with the ROV system during the cruise. A test dive reached the bottom at the beginning of the cruise, but did not complete useful survey. Due to the insufficient dynamic positioning capability of the ship, the ROV was essentially dragged along track during each dive as the ship moved either under power or with wind and current. The ROV pilot would endeavor to keep the ROV oriented so that cameras could image the bottom without disturbing the sediment. Cameras comprised the following:

1) 3-chip, wide angle video camera
2) 1-chip, zoom video camera
3) 1-chip, compact video camera
4) Canon G1 digital still camera

Lighting and camera configurations were modified during each dive. Generally, flood lighting was supplied by a bank of four HID lamps, augmented as needed with quartz lamps. Strobe lighting for the digital still camera was supplied by ~50 watt-sec flash mounted on the upper bar of the ROV. The cameras were mounted to accommodate anticipated dive objectives prior to each dive. Figure 4 shows the camera and lighting configuration as used during the last dive of the cruise.

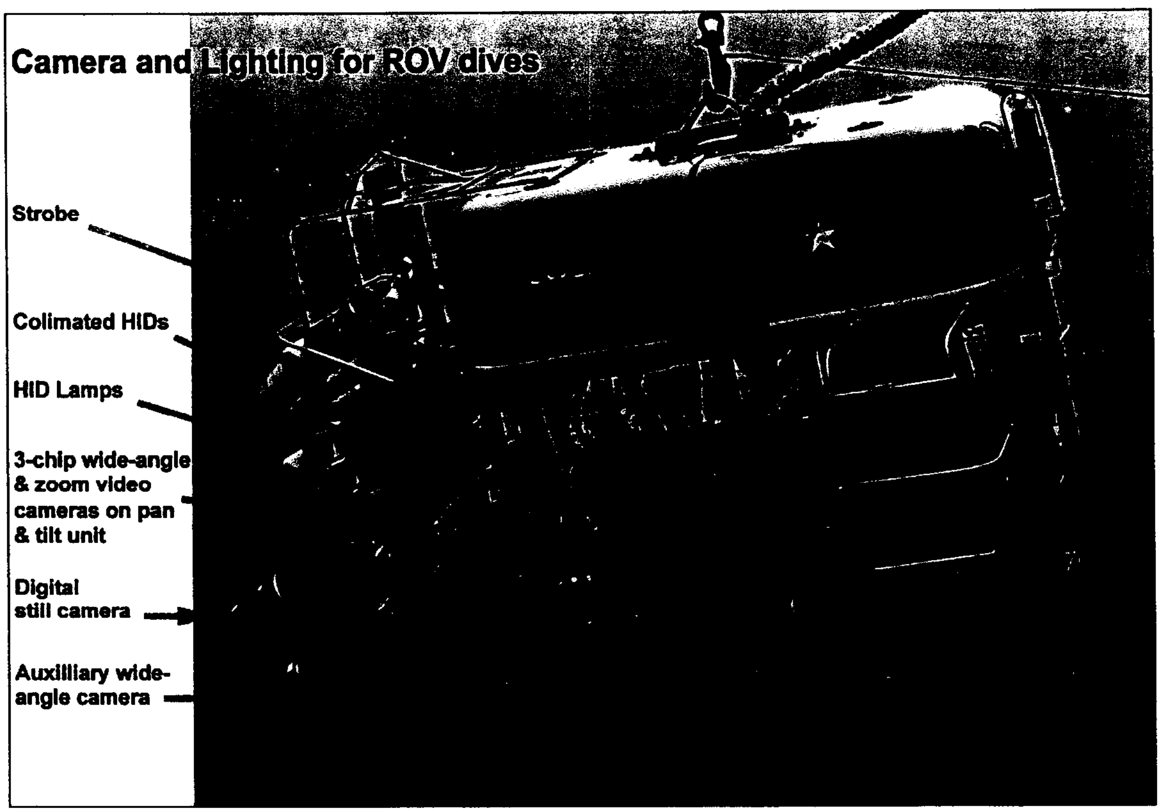

Figure 4. Camera and lighting configuration for ROV dive 7.

During dive 4, a limited amount of sediment was collected with the suction sampler. This device was rendered inoperative during dive 5 and subsequent attempts to collect specimens by other means were unsuccessful. A fish trap was deployed with the ROV on dive 4, but it had to be jettisoned when it fouled the camera system.

The general plan of the dives was to take photos whenever the ROV was close enough to the bottom for effective lighting. There was no attempt to randomize the photography; conspicuous animals, burrows, and other features were actively targeted for photography. Dives continued until scheduling issues or official meal times required termination. None of the benthic dives was terminated due to technical problems with the ROV.

Dives 5 and 6 were helpful in completing the characterization of a site with coarse sediments and relatively few infaunal species. Whereas the boxcores from the NW05/4 and NW01 sites were relatively depopulated, the ROV imaging revealed a diverse community of epifauna associated with cobbles and small boulders.

Dive 7 was particularly successful in terms of combined ROV and box-coring operations. Three cores were completed efficiently prior to the launch of the ROV. The ROV was able to find the site of one box core number 3 by sighting the reflective marker (Figure 5). This novel observation provided a confirmation that the box core was a representative sample of the benthic environment. The camera and lighting configuration during this dive proved adequate for successful imaging of mobile and sessile fauna.

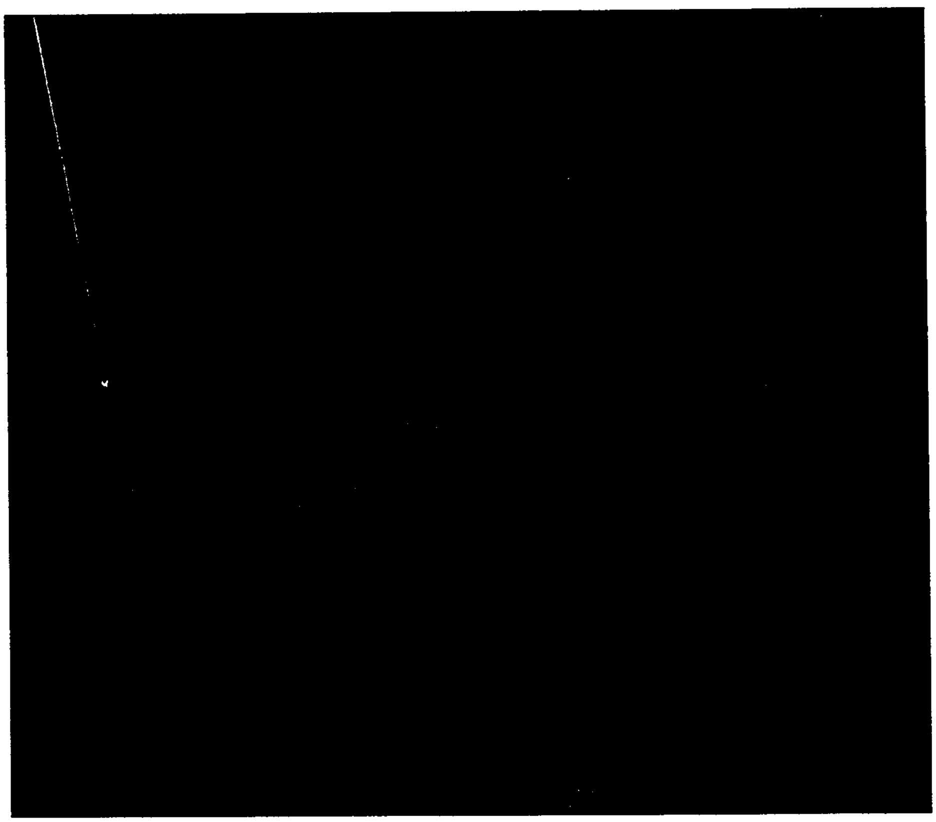

Figure 5. Marker and box core imaged by ROV during dive 7.

PRELIMINARY RESULTS

Objective 1: Identify habitats, species diversity/composition, abundance and biomass of major components of the deep benthic fauna using ROV *in situ* imaging in conjunction with analysis of ROV and box core samples.

The evaluation of the photographic material has commenced with respect to species identification, abundance and distribution, species associations and habitat description (sediment, rocks, lebensspuren etc.). The most common epifauna taxa on the photographic material are fish, crustaceans (amphipods, isopods, decapods), ophiuroids, polychaetes, and anemones (Figures 6 and 7). Where hard bottom was present (western basin), it was occupied by cnidarians, polychaetes, ascidians and crinoids. So far, noteworthy differences between the western / eastern basin include the following: higher energy environment on western slope, more rocks, less lebensspuren, coarser sediment, more suspension feeders; eastern basin: low energy, lebensspuren persist for long time, relatively more deposit/ opportunistic feeders.

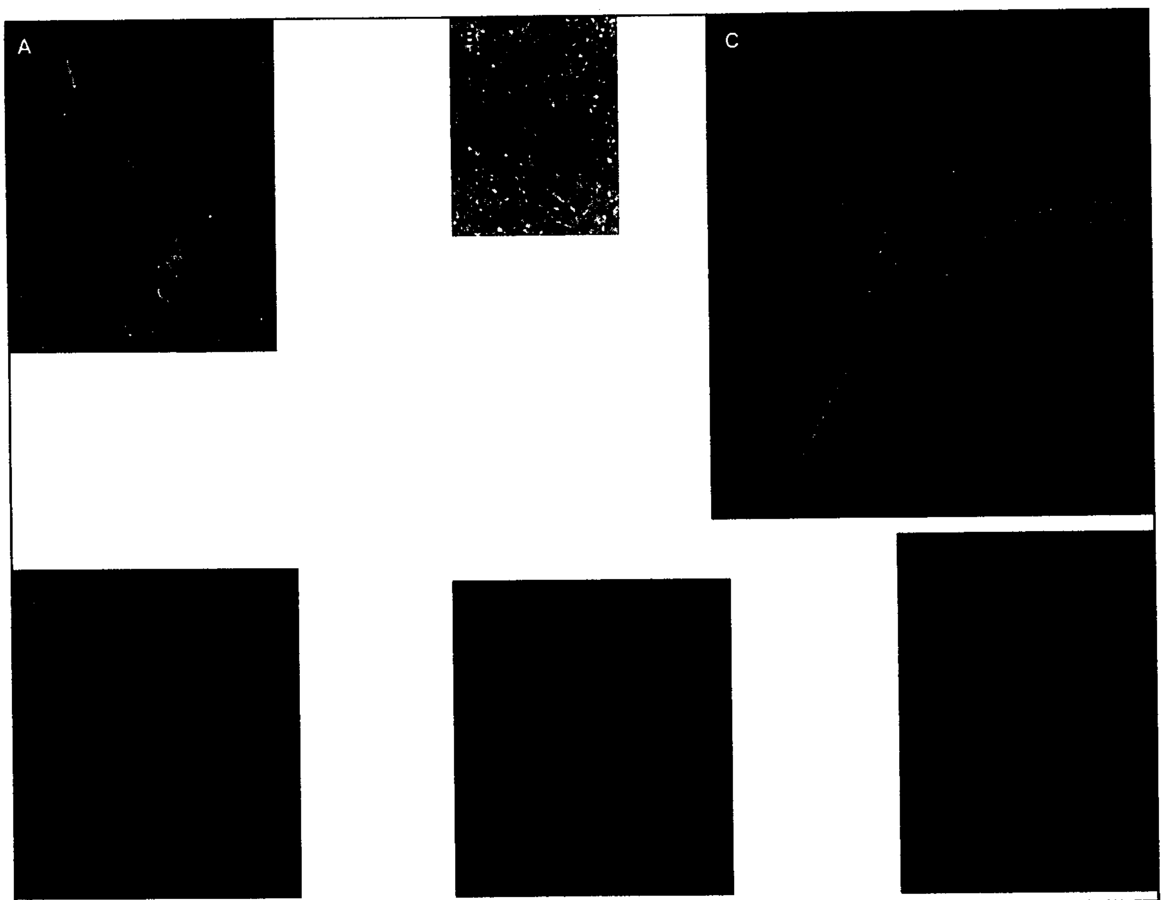

Figure 6. Fish photographed during ROV dives. A snail fish. B sculpin. C skate. D-F three views of common eel pout.

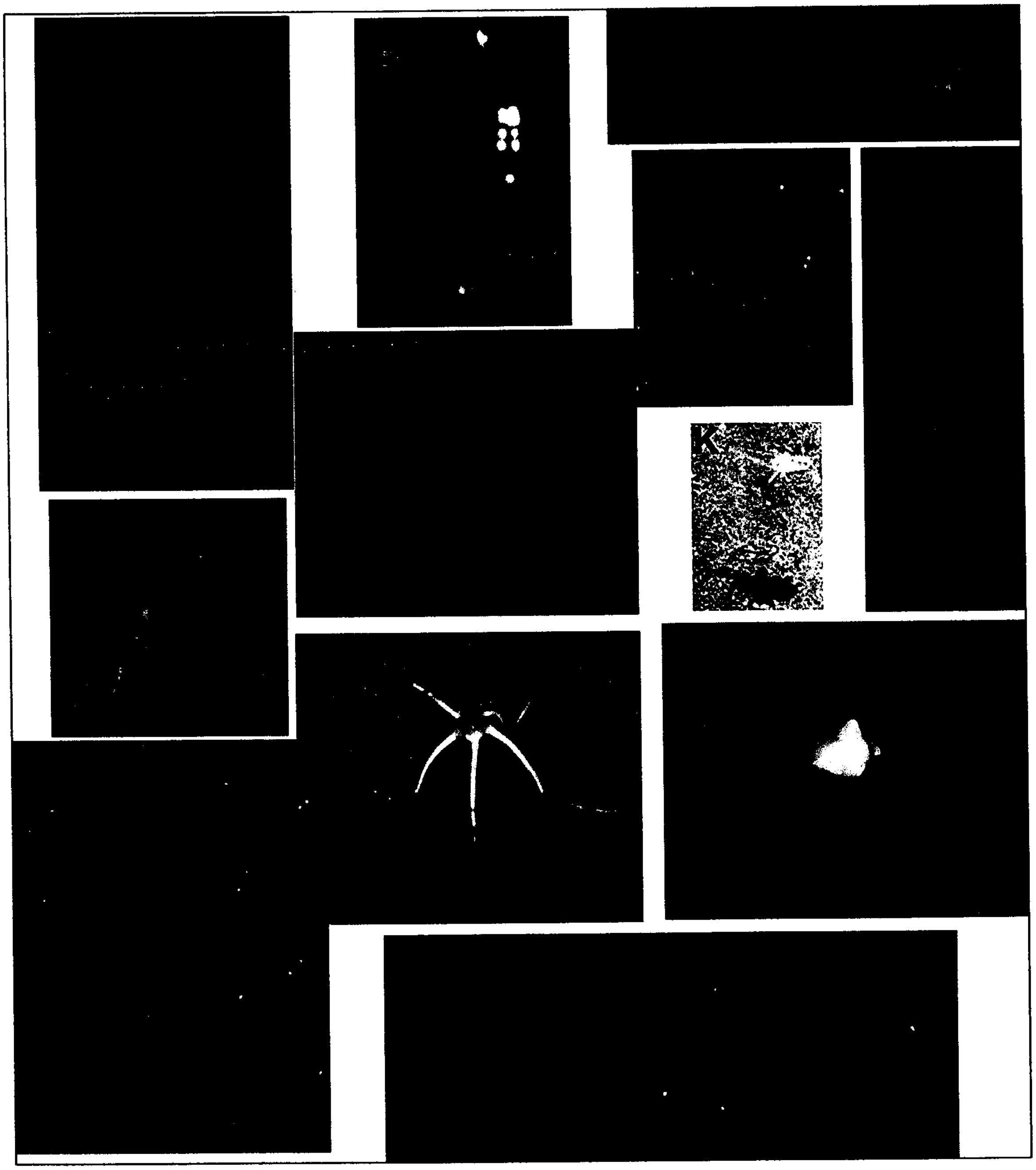

Figure 7. Invertebrate species imaged by ROV. A stalked cnidarian. B polychate with overlapping scales. C & H common isopod and linear trail. D octocorals? F anemone. I tunicate. J ophiuroid. K swimming polychaetes. L crinoid. M asteroid (buried).

The quantitative box core samples are in the process of being sorted by species, and counted and weighed to calculate abundances and biomass. According to first impression, macrofauna abundances, though not necessarily biodiversity, were low, but appeared to vary significantly among stations. Sediment grain size seemed to be a constraint on abundance of macro-infauna at the Northwind Ridge stations, where sand and gravel comprised a major component of the sediments. The dominant infaunal taxa were polychaetes, crustaceans (cumaceans, amphipods, isopods, tanaids), and bivalves.

Our results in terms of dominant infauna are consistent with publications from the Eurasian Arctic deep sea. We will seek assistance with species determination by experts of the respective taxonomic groups once the sorting is completed.

Objective 2: Investigate the food web structure of the benthic community using stable isotope analysis, gut content analysis, and ROV *in situ* imaging.

Tissue or whole organism samples for stable isotope analysis were dried and calcium carbonate was removed prior to analysis by soaking or fuming with concentrated HCl. Individual specimens or pooled samples were measured in duplicate at the stable isotope facility at the University of Alaska Fairbanks. If enough tissue was available, we measured species in replicates of three. Benthic samples were complemented by pelagic (mainly crustaceans) and sea ice samples, and water samples from surface, midwater and bottom water of various stations. Figure 8 gives an overview over the δC^{13} and δN^{15} ratios of pelagic/ice and benthic organisms.

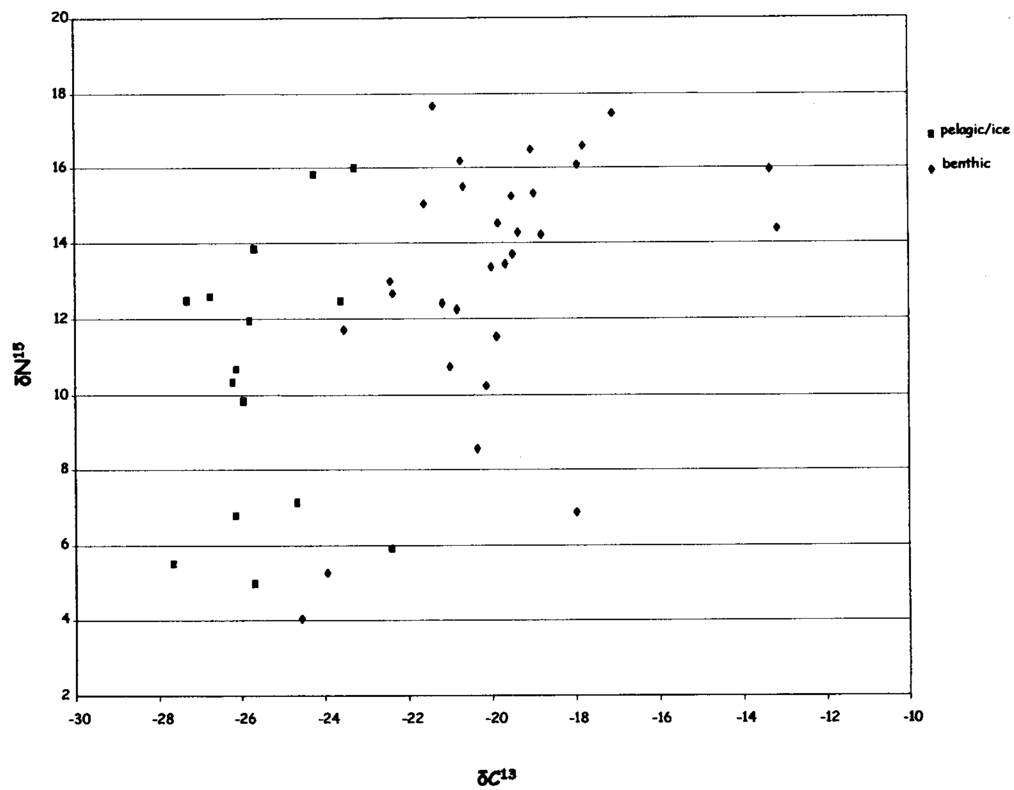

Fig. 8: δC^{13} and δN^{15} ratios of pelagic/ice and benthic organisms.

The δN^{15} ratios are specifically indicative of relative trophic relationships over a wide range of trophic levels. Several studies have shown that δN^{15} shows a stepwise enrichment between trophic levels (TL) of about 4‰. As illustrated in Fig. 9, most benthic organisms are located in the second and third trophic level with respect to the POM (particulate organic matter) value. This means that little fresh phytoplankton or phytodetritus reaches the bottom and most organisms rely on more refractory material as deposit feeders (e.g. many polychaetes), or feed on living or dead animal tissue as scavengers and predators. This trophic pattern is probably related to the scarce input of organic material in the deeper basins of the Arctic Ocean.

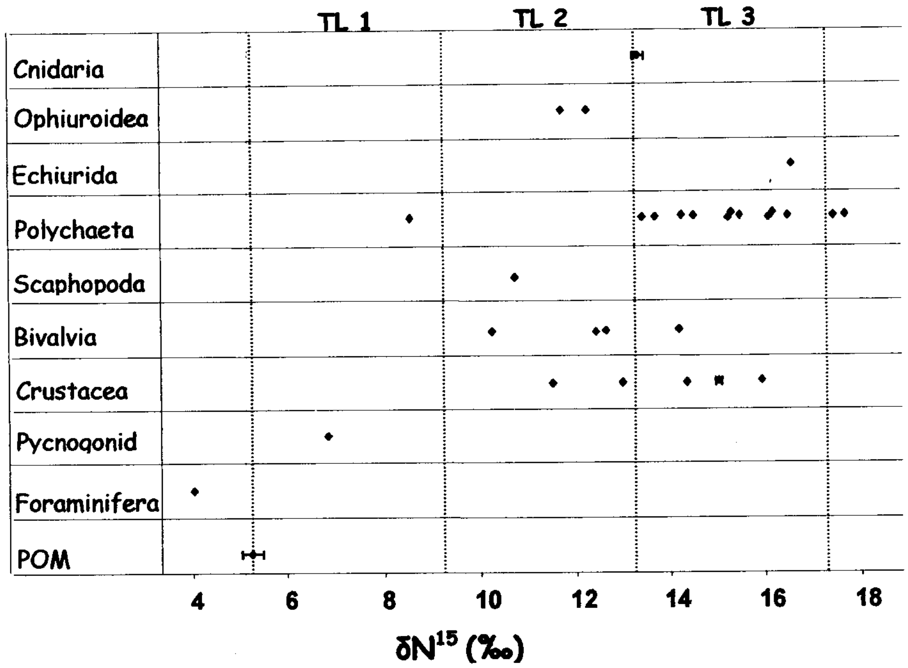

Fig. 9: δN^{15} values of benthic organisms from the Canadian Basin with a hypothetical organization in trophic levels (TL) with reference to POM.

Objective 3: Investigate trophic links between the benthic, pelagic and ice-associated food webs of the deep Arctic Ocean, using stable isotope analysis.

We were also interested in the links between the sea ice, the pelagic and the benthic system. Stable isotope analysis (δN^{15}) revealed that, in contrast to the benthic system, there are distinctive herbivores (TL1) present at the sea ice and the upper water column. Pelagic as well as benthic representatives are found within the second trophic level, while only few pelagic organisms fall within the third TL where most of the benthic organisms are found.

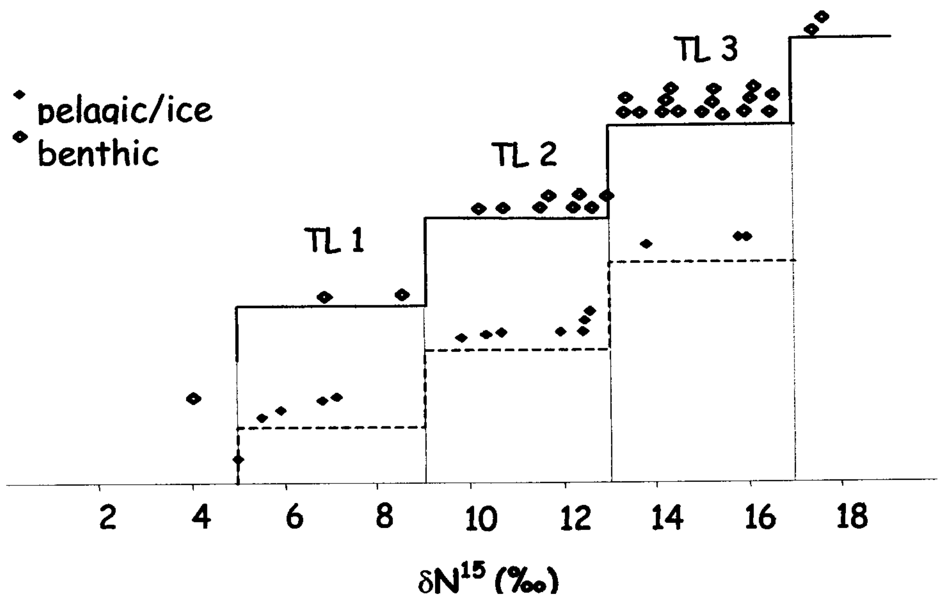

Fig. 10: δN^{15} values of organisms from the Canadian Basin. Comparison of distribution of pelagic/ice associated and benthic organisms among the trophic levels, with reference to POM (bottom most diamond). TL=trophic level.

These results suggest that the link between the pelagic/sea ice and the benthic system is not so much due to direct input of sinking phytodetritus and consumption by the benthos, but more due to grazing of phytoplankton in the water column and subsequent sinking of grazers and their products (e.g. fecal pellets, molts, dead animals) to the seafloor where they provide a major input of organic matter.

Objective 4: Measure levels of pollutants to assess the anthropogenic impact on this remote basin.

Persistent organic pollutants in tissue and sediment will soon be analyzed at the facilities of the Geochemical and Environmental Research Group at Texas A&M University. Additional analyses for total organic carbon and total inorganic carbon will be performed there as well.

Objective 5: Evaluate skeletal remains in the benthos for possible long-term climate records

Observations on skeletal remains included otoliths on Northwind Ridge slope (2000 m), and a large number of other dead remnants such as bivalve, gastropod and scaphopod shells at the same site. These accumulations were not found in other stations and are consistent with information suggesting that this region is a frontal boundary between water masses of Pacific and Atlantic origin. Approximately 150 fish otoliths were collected from four benthic box core samples. Some of the otoliths were sent to out to specialists for species identification, while others are prepared for measurement of δO^{18}.

If this proves possible, the collection could provide a record of water mass characteristics during recent geologic time.

Future perspectives

This exploration expedition facilitated a first glimpse into an under-explored region. It proved the combination of sea floor imaging with ROVs and traditional box cores to be the adequate tools to investigate the Canadian Basin deep sea benthos. For future work, we recommend to utilize the routinely used equipment more efficiently, e.g. by adding still cameras to both the CTD and the box core to complement the images obtained by the ROV without requiring any extra station time. An epibenthic sled or a small Agassiz trawl should be added to sample the mobile epifauna since this is usually missed with both the box core and ROV. These pieces of equipment are light-weight, and thus easy to transport, and have successfully been deployed by members of our working group in both ice-covered waters and the deep-sea. The data set obtained from these first samples will suggest trends in animal abundance, composition and distribution, but needs to be consolidated with more intense sampling. Since densities seems to be low, only a higher number of samples with adequate replication will allow sound conclusion and provide sufficient tissue material for food web and pollutant analysis.

Identification of the specimens collected and photographed during the cruise will require much additional sample processing, review of the photographic material, assistance from experts, and careful review of the literature. Because so little information on these communities exists, the results of this cruise will certainly be a worthwhile contribution to the literature.

Six months report: NOAA Award No: NA16RP2626
Start Date: 6/1/02

Project: The Hidden Ocean: Explorations under the ice of the Western Arctic – life in the crystal palace of sea ice communities

R. Gradinger, B. Bluhm, K. Iken, G. Plumley

Summary

Major activities during the first six months of our project (6/1 – 12/1 2002) included the preparation and participation in an expedition on the Canadian icebreaker "Louis S. St. Laurent". Samples were collected from melt puddles, ice cores and the ice-water interface and were analyzed for the occurrence of microalgae and metazoans. Diver observations augmented our on-ice work with under-ice video transects. Part of the collected material was processed on board, while other samples will be processed within the next six months of the project. Our ideas and activities during the cruise were documented on the NOAA Arctic exploration web pages, local newspapers in Fairbanks and Barrow and local public radio broadcasts.

Expedition objectives

R. Gradinger, B. Bluhm and G. Plumley participated in the cruise. Our working group studied the composition of marine communities related to sea ice. Sampling was conducted on nine stations with sampling times of about 1-4 hours (Fig. 1, Table 1). Our sampling efforts were divided into two major components: a) sampling on the ice and b) sampling under the ice by divers. At four locations we could sample sea ice by means of ice coring, all other locations were sampled with the help of the dive team of the National Geographical Society/ DFO Canada. On-ice sampling was conducted in joint co-operation with the plankton/nutrients working group of T. Whitledge and our two Chinese co-operation partners Qing Zhang and Chen Bo.

On-ice sampling

On ice sampling turned out to be a difficult enterprise on this cruise. Extent of the sea ice was well below average (Fig. 1). Ice floes were small and thin and were covered with melt water puddles at about 40-60%. Our ice-breaking vessel could rarely position itself close enough to the ice to allow a safe transport of scientists and equipment onto the ice. Most study efforts were, therefore, conducted using an FRC (fast recovery craft). Ship regulations limited the number of scientists working simultaneously on the ice to four. In addition, sampling time was restricted by other ship operations, so that fewer samples than expected were collected. All ice core samples were taken in the period August 19 to August 27, 2002.

On-ice sampling included the collection of water from melt ponds and brine holes as well as coring 5 to 8 ice cores per station. The top, one intermediate and the bottom section (each of 15cm length) of the ice cores were collected and brought back to the ship for later analysis.

In situ primary production experiments were conducted on three ice floes with melt pond water and brine in conjunction with Whitledge's group using stable isotopes (^{13}C, $^{15}NO_3$). Whitledge conducted PAR light measurements below the sea ice with our LICOR 4p light sensor as well as under-ice water sampling with our small water sampler (see report by the phytoplankton working group). A YSI85 temperature and salinity probe was lowered through the core holes to study the hydrography in the top 15m of the water column below the sea ice.

Sampling by divers

Sampling by divers was conducted at 8 stations and compensated partially the scarcity of on-ice sampling opportunities. First, video transects of about 30m distance were recorded while the diver was swimming in about 30cm distance to the ice. A PVC pipe attached to the camera housing provided a scale as well as consistent distance from the ice. The recordings were made on a MiniDV system and will be used to estimate abundances and diversity of under-ice amphipod fauna. The divers also recorded the occurrence and abundance of arctic cod (*Boreogadus saida*) in the range of their visibility along the edges of the ice floes.

Ice related fauna was collected in two size fractions (>200μm, 20-200μm) using an under-ice suction hose driven by an on ice pump and filtration system which we specifically developed for that purpose. In addition, 4 l of non-concentrated under-ice water were collected for cell counts and chlorophyll measurements.

Analysis of collected material

Brine, melt pond water and melted ice sections were analyzed onboard for algal pigment composition by HPLC, algal activity (Pulse amplitude modulated (=PAM) fluorometry) and salinity. Co-operation with Q. Zhang (Second Institute of Oceanography, Hangzhou, China) allowed for PAM measurements of melt pond, brine and water samples, establishing a unique data set of photosynthetic characteristics of Arctic microalgae. Subsamples of melt ponds, brine, ice and water sampes were preserved for algal counts. Unpreserved meiofauna samples were sorted and counted using a dissecting scope. Representatives of all metazoan groups were imaged using a video camera and photographic equipment provided by Dr. Hopcroft. Further analysis in the home lab will focus on stable isotope composition (^{13}C, ^{15}N), POC, PON and the structure of the algal and meiofauna communities. Samples from all ice environments (plus some zooplankton taxa) were deep-frozen onboard the Laurent and will be analyzed for their fatty acid composition in co-operation with our project partner Dr. Hagen, Univ. Bremen. Part of the collected material (mainly from melt ponds and brine) was provided to Chen Bo (Polar Research Institute of China, Shanghai, China) for his study of bacterial species composition. Station time was only once sufficiently long to lower a small video camera through a core hole and record two hours of under-ice video. Ice material was provided to the benthic working group (Iken et al.) for stable isotope analysis.

Major findings

No visible coloration of the sea ice by algae or sediment was detected at any location during the entire cruise. Melt ponds covered between 40 to 70% of the surface of the ice floes. Partially the puddles were refrozen. Thickness of the ice floes sampled by ice coring varied between 1.6m and over 4m.

Measurements on algal photosynthetic parameters with the PAM fluorometer were hampered by the low algal biomass in many samples. Reliable data were collected from melt ponds and brine. Those will be compared with measurements from phytoplankton communities in the water column chlorophyll *a* maximum layer (about 40 to 60m depth). No reliable measurements were possible for most surface water samples as the algal fluorescence was too low. A first analysis of the collected data (Fig. 2) reveals that the ice algae were acclimated to higher light intensities than the phytoplankton in the underlying water column: This was indicated by phytoplankton from deeper water layers exhibiting the highest yield and the lowest maximum relative electron transport rate.

We collected preliminary data on the abundance of metazoan animals within and below the sea ice. The sea ice meiofauna consisted mainly of turbellarians, nematodes and harpacticoid copepods (Fig. 3). Diversity was low with each of the three groups represented by probably one species. Total abundance was less than 100 individuals per liter melted sea ice, and the presence was restricted to the lowermost 15cm of the ice floes (bottom layer). Unexpectedly several female copepods carried egg sacks indicating reproduction during the late arctic summer. The collected specimens will be used for species identification. Single individuals were fixed in 70% ethanol for potential later RNA analysis.

Amphipods caught by the divers either directly or with the suction pump belonged to the species *Apherusa glacialis*, *Onisimus* spp. and *Gammarus wilkitzkii*. For *A. glacialis* and *G. wilkitzkii*, both adult animals and juveniles were present. One female *G. wilkitzkii* released a total of 32 juveniles from her marsupium within several days in a tank onboard the ship. The video transects of the first stations (020819, 020820) showed very low abundances of amphipods. Only few specimens of *G. wilkitzkii* were recorded which were either hiding under thin platelets of ice or were moving freely along the ice subsurface. Recordings from the more westerly stations revealed higher abundances of amphipods of all three species. Recordings are of sufficient quality to distinguish adult individuals of *Onisimus* and *Apherusa*. After an initial observation of the occurrence of Arctic cod in gaps along the edges of the ice floes, later systematic surveys proved that this species uses this habitat for resting and/or hiding. The video transects still have to be analyzed for the accurate determination of faunal abundances.

Outreach

Our activities were documented in various ways. Prior to the cruise we informed local communities about our proposed research activities by visiting Barrow, and gave interviews for broadcasts in public radio stations in Barrow and Fairbanks (http://www.uaf.edu/seagrant/NewsMedia/02ASJ/08.30.02hidden-ocean.html) and for a local newspaper (Fairbanks Newsminer). Activities during the cruise were posted on the NOAA Arctic exploration web pages in form of special topics, daily reports and the cruise summary including digital pictures and video sequences in close co-operation with J. Potter (NOAA Arctic Exploration office). Exploration reports were prepared, and are currently in print, for the School of Fisheries and Ocean Sciences monthly newsletter. In addition, a joint "Sea Ice – Deep-sea Benthos" seminar on the Ocean Exploration findings was presented to students, staff and faculty of SFOS in Fairbanks by R. Gradinger and B. Bluhm in October 2002.

Conclusion and outlook

This first Arctic Exploration cruise facilitated a first quick glimpse into an under-explored area. Our study documented that algal and animal biomass within the summer sea ice is low in the Canadian Basin. Representatives of all major taxa, however, which are known from studies in the transpolar drift, were encountered. At this point in the analyses, the most interesting and novel ecological findings are a) the observed reproduction of copepods and amphipods in late summer (rather than in the spring), and b) the use of a spatial niche in melting summer sea ice by the polar cod, *Boreogadus saida*. The collected material will be further analyzed with respect to structure and the ecological niches of the ice associated biota. A detailed study on the ecological significance of this supposedly critical cod habitat within the life cycle of offshore cod would be a challenging and important topic for future investigations. Under-ice amphipods and polar cod are the most important links of carbon from the sea ice to the water columns and higher trophic level, and, therefore, deserve special attention. Moreover, we propose to re-occupy the same and additional stations in the Arctic spring and/or fall to collect seasonal information on life cycles and algal densities related to spring sea ice in the Canadian Basin.

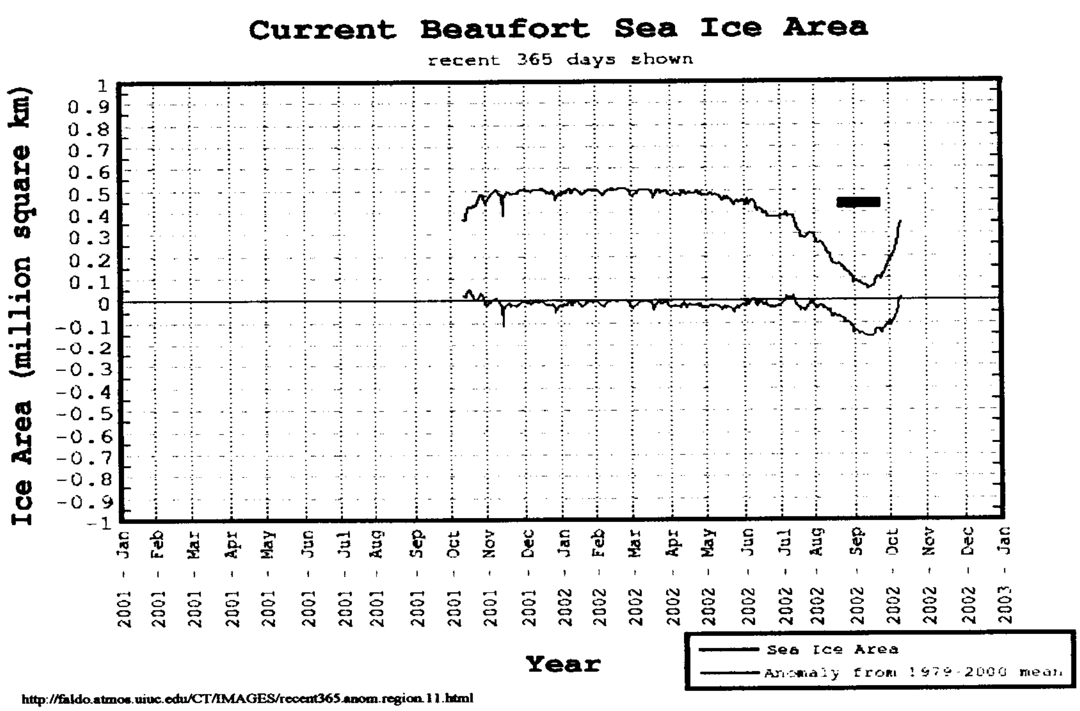

Fig. 1: Ice area and ice anomaly (compared to mean 1979 to 2000) for the Beaufort Sea (since Jan 2001). Green bar represents period of ship's expedition 2002. Modified after http://faldo.atmos.uiuc.edu/CT/IMAGES/recent365.anom.region.11.html.

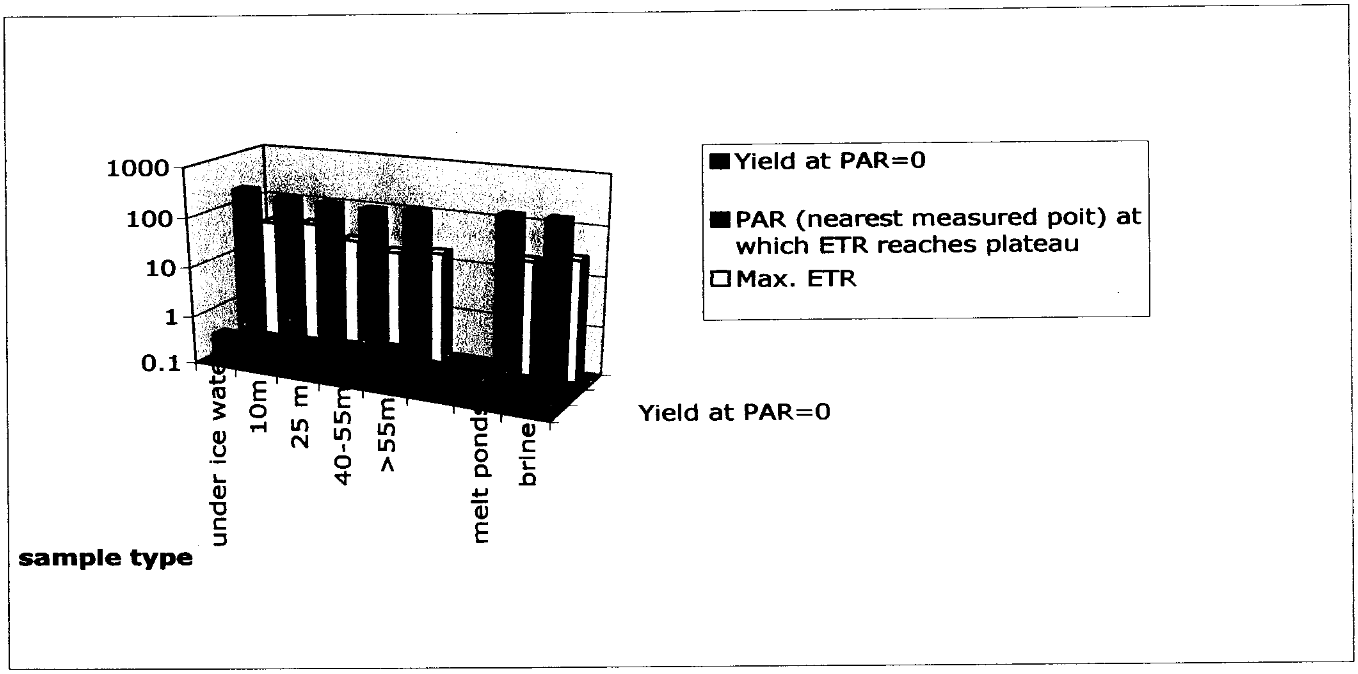

Fig. 2: Mean photophysiological characteristics of microalgae from various Arctic environments. PAR = photosynthetic active radiation (μmol m^{-2} s^{-1}), Yield = photochemical energy conversion at PSII, ETR = relative Electron Transport Rate. A total of 2448 P vs I measurements were conducted with 63 different samples.

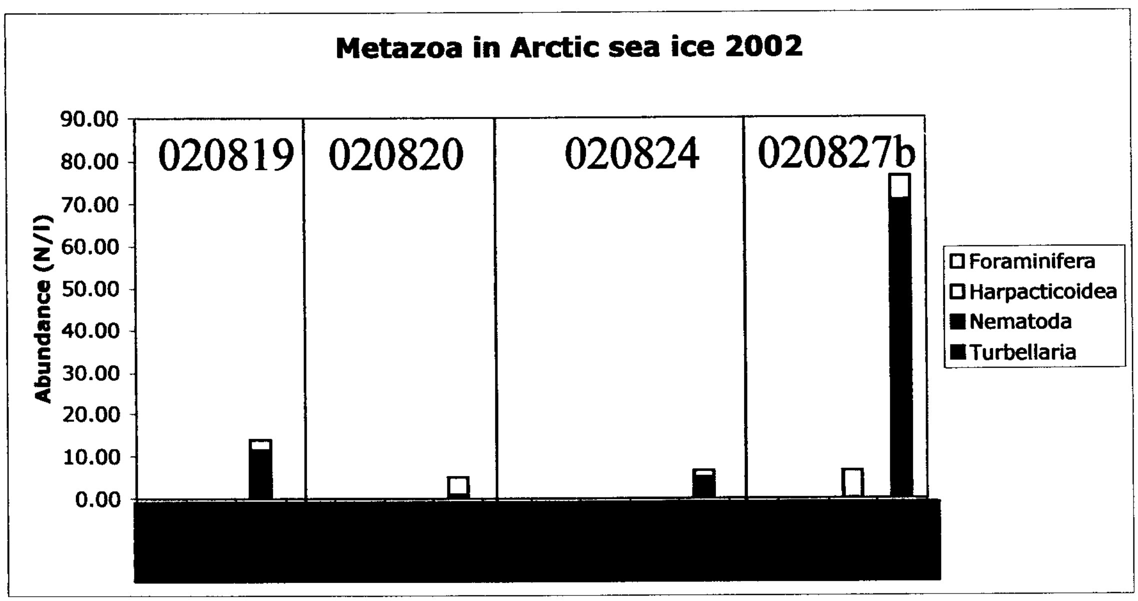

Fig. 3: Abundance (individuals l^{-1}) of main ice meiofauna taxa in sea ice samples from the top (T), interior (I) and bottom (B) of ice floes at the four on-ice stations.

Table 1: Overview of samples taken from various ice-related habitats during the Arctic Ocean Exploration Cruise 2002.

Station	Latitude	Longitude	brine	video transect	ice temperature	in ice biota	melt pond	under-ice hydrography	under-ice water	pump: melt pond	pump: diver	light	in situ PP	traps
20819	72.53	136.32	x	x	x	x	x	x			x	x		
20820	73.30	136.59	x	x	x	x	x	x	x	x	x	x	x	
20822	73.31	138.00	x	x	x	x	x	x			x	x	x	x
20824	72.06	139.50		x			x				x			
20826	74.14	148.22		x							x			
20827A	75.46	148.59		x			x		x					
20827B	76.49	148.17	x		x	x	x	x		x	x	x		x
20828	76.53	148.05		x			x	x	x	x	x			
20831	75.57	155.46		x							x			